

ROUND 17A

TOSS-UP

1) Earth and Space – *Multiple Choice* Which of the following statements is NOT true regarding the planet Mercury?

- W) Mercury is more massive than Ganymede
- X) Mercury has a magnetic field generated by a liquid iron core
- Y) Mercury is synchronously tidally locked with the Sun
- Z) Craters on Mercury's north pole are known to contain water ice

ANSWER: Y) MERCURY IS SYNCHRONOUSLY TIDALLY LOCKED WITH THE SUN

BONUS

1) Earth and Space – *Short Answer* Identify all of the following three quantities that have increased globally due to human activities: 1) Flux of sediment into the oceans from streams; 2) Area of rainforest in the tropics; 3) Total volume of groundwater in aquifers.

ANSWER: 1

~~~~~  
**TOSS-UP**

2) Biology – *Short Answer* Cytochrome proteins contain prosthetic groups that possess what metal center?

ANSWER: IRON

**BONUS**

2) Biology – *Multiple Choice* Which of the following correctly describes the difference between peptoids, or poly-N-substituted glycines, and proteins?

- W) Peptoids have less constrained secondary structure than proteins
- X) Peptoids cannot possess tertiary structure, while proteins can
- Y) Peptoids form more stable alpha helices than proteins
- Z) Peptoids form more stable beta sheets than proteins

ANSWER: W) PEPTOIDS HAVE LESS CONSTRAINED SECONDARY STRUCTURE THAN PROTEINS

**TOSS-UP**

3) Physics – *Multiple Choice* Taking the acceleration due to gravity to be 10 meters per second squared, how much power, in watts, is required to lift a 2 kilogram mass at a constant speed of 2 meters per second?

- W) 2
- X) 4
- Y) 40
- Z) 80

ANSWER: Y) 40

**BONUS**

3) Physics – *Short Answer* Consider the following dispersion relation:  $\omega = 2k^2 - 9k + 6$ . At what two wavenumbers,  $k$ , are the group and phase velocity equal?

ANSWER: SQUARE ROOT OF 3 and NEGATIVE SQUARE ROOT OF 3 (ACCEPT: PLUS OR MINUS SQUARE ROOT OF 3)



**TOSS-UP**

4) Energy – *Multiple Choice* Which of the following would not be considered a balance-of-system component for a stand-alone wind power system?

- W) Battery
- X) Circuit breaker
- Y) Inverter
- Z) Turbine

ANSWER: Z) TURBINE

**BONUS**

4) Energy – *Short Answer* What compound, traditionally added as an anti-knocking additive to gasoline, was banned in the United States in 1996 due to health and environmental concerns?

ANSWER: TETRAETHYL LEAD (ACCEPT: TEL, DO NOT ACCEPT: LEAD)

### TOSS-UP

5) Chemistry – *Multiple Choice* Which of the following ions is most similar in ionic radius to the cation  $\text{Na}^+$ ?

- W)  $\text{K}^+$
- X)  $\text{Rb}^+$
- Y)  $\text{Mg}^{2+}$
- Z)  $\text{Ca}^{2+}$

ANSWER: Z)  $\text{Ca}^{2+}$

### BONUS

5) Chemistry – *Short Answer* Identify all of the following three organic acids that would be more acidic in water than in acetic acid: 1) Chloroacetic acid; 2) Formic acid; 3) Propanoic acid.

ANSWER: 1 AND 2 (ACCEPT: CHLOROACETIC ACID AND FORMIC ACID)

~~~~~

TOSS-UP

6) Math – *Multiple Choice* Which of the following describes the solutions for the equation x to the x power = x to the $x + 1$ power?

- W) -1 and 1
- X) 0
- Y) 1
- Z) No solution exists

ANSWER: Y) 1

BONUS

6) Math – *Short Answer* What is the sum of the first 6 terms in the geometric sequence with first term 3 and second term 12?

ANSWER: 4095

TOSS-UP

7) Physics – *Multiple Choice* A disc originally at rest moves through 6 radians as it undergoes a constant angular acceleration about its central axis. If the time taken to accelerate is 2 seconds, what is the magnitude of the acceleration in radians per square second?

- W) 3
- X) 6
- Y) 9
- Z) 12

ANSWER: W) 3

BONUS

7) Physics – *Multiple Choice* Which of the following types of magnetometers needs to be cooled to very low temperatures due to reliance on the Josephson effect?

- W) Overhauser
- X) SERF [*surf*]
- Y) SQUID [*squid*]
- Z) Fluxgate

ANSWER: Y) SQUID

~~~~~

### TOSS-UP

8) Chemistry – *Short Answer* The rate of a reaction between reagent A and reagent B is first order in B. By what factor is the rate of reaction multiplied if the concentration of reagent B is doubled?

ANSWER: 2

### BONUS

8) Chemistry – *Short Answer* What process, whose first oxidative step is catalyzed in the atmosphere by dust grains and industrially by vanadium pentoxide, generates oleum, which is reacted with water to make sulfuric acid?

ANSWER: CONTACT PROCESS

**TOSS-UP**

9) Biology – *Multiple Choice* Which of the following lengths of DNA would be least likely to be unwound by a passive helicase?

- W) ATATAT
- X) AAATTT
- Y) TTTGGG
- Z) GCGCGC

ANSWER: Z) GCGCGC

**BONUS**

9) Biology – *Short Answer* Bacteria use what cellular structure for motility?

ANSWER: FLAGELLUM



**TOSS-UP**

10) Earth and Space – *Short Answer* Identify all of the following three phenomena that are formed by aeolian processes: 1) Yardangs; 2) Ventifacts; 3) Dunes.

ANSWER: ALL OF THEM

**BONUS**

10) Earth and Space – *Short Answer* Identify all of the following three events that occurred during the recombination epoch of the Big Bang: 1) Formation of neutral hydrogen; 2) Neutrino decoupling; 3) Star formation.

ANSWER: 1 ONLY

**TOSS-UP**

11) Energy – *Multiple Choice* Lithium cobalt oxide is most commonly used for what component of a lithium-ion battery?

- W) Electrolyte
- X) Cathode
- Y) Enclosure
- Z) Anode

ANSWER: X) CATHODE

**BONUS**

11) Energy – *Multiple Choice* What country used 100% renewable energy for 75 consecutive days in 2015?

- W) Lesotho [*leh-SOH-toh*]
- X) Costa Rica
- Y) Norway
- Z) Sweden

ANSWER: X) COSTA RICA



**TOSS-UP**

12) Math – *Short Answer* The point (3, -7) is reflected through the y-axis, with the result then translated 2 units left. What are the coordinates of the final image?

ANSWER: (-5, -7)

**BONUS**

12) Math – *Short Answer* What is the distance between the two points with polar coordinates of  $r = 4$  and  $\theta = 60$  degrees, and  $r = 6$  and  $\theta = 0$  degrees?

ANSWER:  $2\sqrt{7}$

**TOSS-UP**

13) Biology – *Short Answer* Identify all of the following three conditions that negatively impact short term memory: 1) Post traumatic stress disorder; 2) Aphasia [*ah-FAY-sjah*]; 3) Alzheimer's.

ANSWER: 1, 2, 3 (ACCEPT: ALL OF THEM)

**BONUS**

13) Biology – *Short Answer* What organelle is defective in inclusion-cell disease, also known as I-cell disease?

ANSWER: LYSOSOME



**TOSS-UP**

14) Math – *Short Answer* What is the average of the integers from 1 to 21, inclusive?

ANSWER: 11

**BONUS**

14) Math – *Short Answer* If air leaves a spherical balloon at a rate of 1 cubic centimeter per second, at what rate in centimeters per second is the radius changing when the radius is 1/2 centimeter?

ANSWER:  $-1/\pi$  (ACCEPT: DECREASING BY  $1/\pi$ ; DO NOT ACCEPT:  $1/\pi$ )

**TOSS-UP**

15) Chemistry – *Short Answer* What scientist, whose graduate students Geiger and Marsden performed an experiment that involved shooting alpha particles at a metallic foil, was the first to propose that an atom consisted of a dense positively-charged nucleus with mobile electrons surrounding the nucleus?

ANSWER: ERNEST RUTHERFORD (ACCEPT: RUTHERFORD)

**BONUS**

15) Chemistry – *Short Answer* Identify all of the following three statements that are TRUE concerning crystal field theory: 1) Carbon monoxide is a strong-field ligand; 2) Tetrahedral splitting is larger than octahedral splitting; 3) Square planar compounds can be chiral.

ANSWER: 1

~~~~~

TOSS-UP

16) Energy – *Multiple Choice* What biological carbon sequestration method uses iron and requires a better understanding of iron cycling in marine systems to determine its long-term impacts?

- W) Iron geo-reduction
- X) Iron sequestration
- Y) Iron filtering
- Z) Iron fertilization

ANSWER: Z) IRON FERTILIZATION

BONUS

16) Energy – *Short Answer* Recent work at Lawrence Berkeley National Laboratory has linked what metal to the health of the brain, showing that improper oxidation is not only linked to Alzheimer's disease, but also that it modulates spontaneous activity in developing circuits?

ANSWER: COPPER

TOSS-UP

17) Physics – *Multiple Choice* The current in a cathode ray tube is 10 nanoamps. Which of the following is closest to the number of electrons striking the face of the glass tube each second?

- W) 3.6×10^{10}
- X) 6.3×10^{10}
- Y) 3.6×10^{11}
- Z) 6.3×10^{11}

ANSWER: X) 6.3×10^{10}

BONUS

17) Physics – *Short Answer* List two of the experiments performed at the Large Hadron Collider at CERN in Europe.

ANSWER: Any two of the following: ATLAS, CMS, LHCb, ALICE, ToTEM, LHCf, MoEDAL



TOSS-UP

18) Earth and Space – *Short Answer* What allotrope of carbon is known for its strong bonds within the plane, but weak bonds between planes?

ANSWER: GRAPHITE (DO NOT ACCEPT: GRAPHENE)

BONUS

18) Earth and Space – *Multiple Choice* Which of the following regions of an active galactic nucleus is the most distant from the supermassive black hole?

- W) Accretion disk
- X) Broad line region
- Y) Narrow line region
- Z) Obscuring torus

ANSWER: Y) NARROW LINE REGION

TOSS-UP

19) Chemistry – *Short Answer* Rank the following three solid structures from the one with the lowest coordination number to the one with the highest: 1) Body-centered cubic; 2) Hexagonal closest-packed; 3) Simple cubic.

ANSWER: 3, 1, 2 (ACCEPT: SIMPLE CUBIC, BODY-CENTERED CUBIC, HEXAGONAL CLOSEST-PACKED)

BONUS

19) Chemistry – *Short Answer* What rule, which can be explained by the preferential stability of highly substituted carbocations, predicts that the major product in an elimination reaction with an unhindered base is the most substituted alkene?

ANSWER: ZAITSEV'S RULE

~~~~~

**TOSS-UP**

20) Math – *Short Answer* Simplify  $i$  raised to the 22nd power.

ANSWER:  $-1$

**BONUS**

20) Math – *Short Answer* In a circle with radius 4, what is the area of a circular segment defined by an arc of  $45^\circ$ ?

ANSWER:  $2\pi - 4\sqrt{2}$

### TOSS-UP

21) Earth and Space – *Short Answer* Refracting telescopes have a severe limitation in that each wavelength of light is refracted differently, making it impossible to focus on more than one wavelength of light at a time. What is this type of optical aberration called?

ANSWER: CHROMATIC ABERRATION (ALSO ACCEPT: CHROMATIC DISTORTION, SPHEROCHROMATISM)

### BONUS

21) Earth and Space – *Multiple Choice* A red breccia contains a high percentage of large angular feldspar grains. In what type of depositional environment would you expect it to have formed?

- W) Beach
- X) Alluvial fan
- Y) Deep ocean trench
- Z) River delta

ANSWER: X) ALLUVIAL FAN

---

### TOSS-UP

22) Biology – *Multiple Choice* Which of the following nucleobases is NOT a pyrimidine [*pur-RIM-ih-deen*]?

- W) Guanine [*GWAH-neen*]
- X) Cytosine [*SYE-toh-seen*]
- Y) Thymine [*THIGH-meen*]
- Z) Uracil [*YUR-ah-sil*]

ANSWER: W) GUANINE

### BONUS

22) Biology – *Multiple Choice* Which of the following immune cells is most involved in defense against parasites?

- W) Neutrophils
- X) Eosinophils [*ee-oh-SIN-oh-filz*]
- Y) Basophils [*BAY-zoh-filz*]
- Z) Mast cells

ANSWER: X) EOSINOPHILS

**TOSS-UP**

23) Physics – *Short Answer* How much energy, in joules, is in a single kilo-watt hour?

ANSWER: 3.6 MILLION (ACCEPT: 3 MILLION 6 HUNDRED THOUSAND)

**BONUS**

23) Physics – *Short Answer* Studies of neutral kaon oscillations resulted in the discovery of what symmetry violation in particle physics?

ANSWER: CP VIOLATION